FOOT ORTHOTIC FOR SUPPORTING AN ARCH OF A FOOT, AND RELATED METHODS

Cross-Reference To Related Applications

[1] This application claims priority from commonly owned U.S. Provisional Patent Application 60/408,140 titled INSOLE WITH ARCH SUPPORT, presently pending, which is hereby incorporated by reference in its entirety.

Background

[2] Many people use an orthotic to help support their feet when they stand, walk, run and/or otherwise use their feet. In general, feet suffer abuse during such activities because a person's feet bears the loads generated by the person's weight, which can be many times greater than the persons weight when the person walks, runs or is otherwise physically active. In addition, because most shoes today are mass produced, the insole of many shoes is not designed and contoured for a specific person's foot. Consequently, many shoes today fail to adequately support a person's foot and do not prevent a person's foot from prematurely tiring and/or aching.

[3] FIGS. 1, 2A and 2B show a conventional orthotic 10 frequently used to support the arch of a person's foot. The orthotic 10 includes a top surface 12 having an arch portion 14 contoured to receive a person's arch, and a bottom surface 16 having a mid-plantar portion 18. The mid-plantar portion 18 includes ribs 20 and 22 (six shown but only four labeled for clarity) to resist the deformation of the arch portion 14 when a person exerts pressure on the arch portion 14 with his/her foot. The ribs 20 extend across the mid-plantar portion 18 linearly — in a straight or substantially straight line — in a fore and aft direction 24, and the ribs 22 extend across the mid-plantar portion 18 linearly in a direction 26 perpendicular to the fore and aft direction 24. The orthotic 10 also

includes cavities 28 (fifteen shown but only one labeled for clarity) formed by the ribs 20 and 22 to provide the orthotic 10 flexibility.

[4] Unfortunately, the orthotic 10 often fails to adequately support a foot's arch after moderate use. Cracks frequently form in the ribs 20 and 22 where these ribs 20 and 22 intersect with each other, and where the ribs 20 and 22 extend from the floors 30 (fifteen shown but only one labeled for clarity) of the cavities 28. In addition, the arch portion 14 frequently becomes permanently deformed. The cracks and/or permanent deformation develop because the force generated during each step or while standing is large and not effectively carried by the ribs 20 and 22 in the mid-plantar portion 18.

[5] The force generated by walking generally aligns fore and aft in the orthotic 10. This force is carried by the material through each of the orthotic's cross-sections (see FIGS. 2A and 2B) oriented perpendicular to the fore and aft direction 24. The ability of the material to effectively carry the force depends on the area of the perpendicularly oriented cross-sections. The smaller the area the more concentrated the force becomes and the less efficient the cross-section carries the force. Furthermore, this efficiency decreases as the change in the cross-sectional area between adjacent cross-sectional areas increases and becomes more abrupt.

[6] Referring to FIGS. 2A and 2B, because the cross-sectional area 32 of the mid-plantar portion 18 changes significantly and abruptly at the intersection of the ribs 20 and 22 with each other, and where the ribs 20 and 22 extend from the floors 30, the force concentrates as it passes from a cross-section of the mid-plantar portion 18 that does not include a cavity 28 (see FIG. 2A) to a cross-section of the mid-plantar portion 18 that includes a cavity 28 (see FIG. 2B). Thus, cracks and tears typically form at locations 34 (only two shown in FIGS. 1 and 2B for clarity) after moderate use of the orthotic 10.

[7] A common method of preventing cracks from prematurely forming is to make the ribs 20 and 22 from a stiffer material. But this typically removes flexibility from the mid-plantar portion 18 making the orthotic 10 uncomfortable to use while walking and/or running. Another common method of preventing cracks from prematurely forming is to

make the mid-plantar portion 18 from a more flexible material. But this typically reduces the amount of support the mid-plantar portion 18 provides.

Summary

[8] The present invention provides an orthotic that supports the arch of a foot during and after extensive use and is flexible to allow a person to comfortably walk and/or run. The orthotic comprises a bottom surface including a mid-plantar region having a perimeter that includes a front portion, a rear portion opposite the front portion, a left side portion and a right side portion opposite the left side portion, and a plurality of longitudinal and lateral ribs in the mid-plantar region. Each longitudinal rib extends toward the front and rear portions of the perimeter but not across the mid-plantar region. And each lateral rib extends from a respective longitudinal rib toward one of the side portions of the perimeter and forms an angle with the respective longitudinal rib that is greater than 90°. Because the angular relationship between the longitudinal and lateral ribs is greater than 90°, the stress concentrated in the intersection of the longitudinal ribs with the lateral ribs is reduced when the mid-plantar region is flexed. And, the change in cross-sectional area between adjacent cross-sections perpendicularly oriented to the force aligned fore and aft is less abrupt. Thus, the orthotic may be made flexible to provide comfort while walking, running or performing other physical activities, and strong to support a foot during and after much use.

[9] In another aspect of the invention, the orthotic may include a plurality of curved longitudinal ribs and curved lateral ribs to reduce the stress concentrated in the longitudinal and lateral ribs when the mid-plantar region is flexed. Each curved longitudinal rib may extend toward the front and rear portions of the perimeter but not across the mid-plantar region. And each lateral rib may extend from a respective longitudinal rib toward one of the side portions of the perimeter.

Brief Description Of The Figures

[10] FIG. 1 is a perspective view of a conventional orthotic for supporting the arch of a foot.

[11] FIG. 2A is a cross-sectional view of the orthotic in FIG. 1 showing a portion of the orthotic as indicated in FIG. 1.

[12] FIG. 2B is another cross-sectional view of the orthotic in FIG. 1 showing another portion of the orthotic as indicated in FIG. 1.

[13] FIG. 3 is a perspective view of an orthotic according to an embodiment of the invention.

[14] FIG. 4 is a plan view of the orthotic in FIG. 3.

[15] FIG. 5A is a cross-sectional view of the orthotic in FIG. 3 showing a portion of the orthotic as indicated in FIG. 4.

[16] FIG. 5B is a second cross-sectional view of the orthotic in FIG. 3 showing a portion of the orthotic as indicated in FIG. 4.

[17] FIG. 6A is a third cross-sectional view of the orthotic in FIG. 3 showing a portion of the orthotic as indicated in FIG. 4.

[18] FIG. 6B is a fourth cross-sectional view of the orthotic in FIG. 3 showing a portion of the orthotic as indicated in FIG. 4.

[19] FIG. 7 is a perspective view of an orthotic according to another embodiment of the invention.

Detailed Description

[20] The following discussion is presented to enable one skilled in the art to make and use the invention. Various modifications to the disclosed embodiments will be readily apparent to those skilled in the art, and the generic principles herein may be applied to

other embodiments and applications without departing from the spirit and scope of the present invention as defined by the appended claims. Thus, the present invention is not intended to be limited to the embodiments shown, but is to be accorded the widest scope consistent with the principles and features disclosed herein.

[21] FIG. 3 is a perspective view of an orthotic 40 according to an embodiment of the invention. When the orthotic 40 is worn, the orthotic 40 supports the arch of a person's foot to reduce pain and premature tiring that often occurs from being on his/her feet for a long period of time. The orthotic 40 includes a bottom surface 42 having a mid-plantar region 44 that supports the arch of a person's foot, and a top surface 46 having an arch region 48 that is contoured to distribute pressure exerted on the arch region 48 by the person's arch to the mid-plantar region 44. The orthotic 40 also includes longitudinal ribs 50 (seven shown but only four labeled for clarity) and lateral ribs 52 (sixteen shown but only six labeled for clarity) in the mid-plantar region 44 that allow the mid-plantar region 44 to flex in response to the pressure exerted by the person's foot while supporting the person's arch. Each longitudinal rib 50 intersects with a respective lateral rib 52 and forms an angle that is greater than 90° to reduce the concentration of stress generated in the intersections 54 (twelve shown but only four labeled for clarity) of the longitudinal ribs 50 with the lateral ribs 52. By reducing the stress concentrated in the ribs 50 and 52, the orthotic 40 can support a person's arch longer than a conventional orthotic can.

[22] The mid-plantar region 44 includes a perimeter 56 having a front portion 58, a rear portion 60 opposite the front portion 58, a left side portion 62, and a right side portion 64 opposite the left side portion 62. When a person stands, walks or runs with the orthotic 40 supporting his/her arch, much of the force exerted on the mid-plantar region 44 is generally aligned toward the front and rear portions 58 and 60, respectively. Consequently, the stress generated in the longitudinal and lateral ribs 50 and 52 at a location in the mid-plantar region 44 depends on the cross-sectional area of the mid-plantar region 44 perpendicularly oriented between the front and rear portions 58 and 60 at the location. As the cross-sectional area changes from one location to another, stress frequently concentrates in portions of a cross-sectional area and

diffuses in other portions of the cross-sectional area. The stress concentrates in portions of a cross-sectional area where the force carried by the cross-sectional area is directed in a direction different than the direction the adjacent cross-sectional area directs the force in. For example, a force aligned toward the front portion 58 of the mid-plantar's perimeter 56 and redirected at an intersection 54 of a longitudinal rib 50 with a lateral rib 52 causes stress to concentrate in the intersection 54.

[23] By extending each lateral rib 52 from a respective longitudinal rib 50 at an angle greater than 90°, the redirection of the force at the intersection 54 is mitigated and the change in cross-sectional area through the intersection 54 (shown and discussed in greater detail in conjunction with FIGS. 5A – 6B) is less abrupt. Thus, the stress concentrations in the intersections 54 are reduced and the longitudinal and lateral ribs 50 and 52 are better able to withstand the rigors of repeated use. Thus, the orthotic 40 may be made strong to support a foot during and after much use.

[24] Still referring to FIG. 3, the longitudinal and lateral ribs 50 and 52, respectively, may be arranged in the mid-plantar region 44 as desired to help provide the mid-plantar region 44 flexibility. For example, the longitudinal and lateral ribs 50 and 52, respectively, may form cavities 66 (twelve shown and discussed in greater detail in conjunction with FIG. 4 but only one labeled for clarity). In addition, each cavity 66 may or may not include a hole 68 (twelve shown but only one labeled for clarity) to allow air to pass from the cavity 66 toward the arch portion 48. Thus, the orthotic 40 may be made flexible enough to provide comfort while walking, running or performing other physical activities.

[25] Still referring to FIG. 3, the arch region 48 can have any desired contour for supporting a foot's arch. For example, the arch region 48 can include a complex convex curve formed from a standard model of a foot's arch or a cast of a particular user's arch. Additionally or alternatively, the arch region 48 can include a spherical or substantially spherical curve.

[26] FIG. 4 is a plan view of the orthotic 40 in FIG. 3 and shows the location of two sets of cross-sectional areas that are shown in FIGS. 5A – 6B (one set is shown in

FIGS. 5A and 5B, and the other set is shown in FIGS. 6A and 6B) and discussed in conjunction therewith.

[27] The longitudinal ribs 50 (seven shown but only two labeled for clarity) and the lateral ribs 52 (sixteen shown but only four labeled for clarity) may extend throughout the mid-plantar region 44 to form any desired relief pattern that includes cavities 66 (twelve shown but only one labeled for clarity) having any desired shape as long as no longitudinal rib 50 extends across the mid-plantar region. In addition, the angle formed by the ribs 50 and 52 at the intersections 54 may be any angle greater than 90°. For example, in one embodiment the angle formed at an intersection 54 may be 120°. The ribs 50 and 52 may extend linearly or in a straight or substantially straight line and form a plurality of cavities 66 that include substantially hexagonal cavities, substantially pentagonal cavities and substantially trapezoidal cavities.

[28] Other embodiments are contemplated. For example, the cavities may be octagonal and the angle formed between the ribs 50 and 52 may be 110°.

[29] Still referring to FIG. 4, the orthotic 40 can be made of any desired material using any desired manufacturing process. For example, the orthotic 40 can be made from ethyl vinyl acetate injected into a mold. Or the orthotic 40 can be made from other thermoplastic materials, rubbers or silicones.

[30] Other embodiments are contemplated. For example, the orthotic 40 may include a laminate made from any desired material such as thermoplastic material, rubber or silicone to provide shock absorption, additional structural support, or a wear resistant surface. The laminate may be attached to the orthotic 40 by overmolding the laminate. Or the laminate may be inserted into the orthotic 40 during the molding process. As another example, the orthotic 40 may be impregnated with metallic particles that are magnetic or can be magnetized to generate a therapeutic magnetic field. Or the orthotic 40 may be impregnated with copper particles for subsequent absorption by the user when using the orthotic 40 without socks.

[31] FIGS. 5A, 5B, and 6A and 6B each show a cross-sectional area 70, 72, 74, 76, respectively, of the mid-plantar region 44 (FIG. 3) of the orthotic 40 (FIG. 3) at a

different location in the mid-plantar region 44. As indicated in FIG. 4, FIGS. 5A and 5B show different cross-sectional areas 70 and 72 as a longitudinal rib 50 intersects two lateral ribs 52, and FIGS. 6A and 6B show different cross-sectional areas 74 and 76 as two lateral ribs 52 intersect a longitudinal rib 50. By mitigating the change between the cross-sectional areas 70 and 72, and between the cross-sectional areas 74 and 76, the concentrations of stress in the ribs 50 and 52 are reduced.

[32] Referring to FIGS. 5A – 6B, the ribs 50 and 52 may be any desired shape having any desired thickness and height to stiffen and support the arch region 48, and thus, support the arch of a person's foot. For example, in one embodiment each of the ribs 50 and 52 may be about 0.19 inches thick and have a height equal to about 90% of the thickness of the orthotic 40 in the mid-plantar and arch regions 44 and 48, respectively. The shape of each rib 50 and 52 may be substantially rectangular or trapezial, *i.e.*, a four-sided shaped where none of the sides are parallel.

[33] Other embodiments are contemplated. For example, the shape of each rib 50 and 52 may be circular, triangular and/or pentagonal.

[34] Referring to FIGS. 5A and 5B, the cross-sectional area 72 (FIG. 5B) is greater than the cross-sectional area 70 (FIG. 5A). Thus, an increase in the force aligned toward the front and rear portions 58 and 60, respectively, should not concentrate the stress in the intersection 54 to a level that could cause the ribs 50 and 52 to tear.

[35] Referring to FIGS. 6A and 6B, the cross-sectional area 76 (FIG. 6B) is less than the cross-sectional area 74 (FIG. 6A). Thus, an increase in the force aligned toward the front and rear portions 58 and 60, respectively, will concentrate the stress in the intersection 54, which may cause the ribs 50 and 52 to tear. But because the angle between the longitudinal rib 50 and the lateral ribs 52 is greater than 90° at the intersection 54, the concentration of stress is mitigated and the ribs 50 and 52 are less likely to tear compared to a conventional orthotic that includes angles between longitudinal and lateral ribs that are 90° or less.

[36] FIG. 7 is a perspective view of an orthotic 80 according to another embodiment of the invention. The orthotic 80 is similar to the orthotic 40 except some of the longitudinal ribs 82 (eight shown but only six labeled for clarity) and some of the lateral ribs 84 (seventeen shown but only three labeled for clarity) curve as they extend toward respective portions 86, 88, 90 and 92 of the perimeter 94 of the mid-plantar region 96. With some of the longitudinal and lateral ribs 82 and 84 curved, the concentration of stress in the ribs 82 and 84 is mitigated when the mid-plantar region 96 is flexed.

[37] The longitudinal and lateral ribs 82 and 84, respectively, may be arranged in the mid-plantar region 96 as desired to help provide the mid-plantar region 96 flexibility. For example, the longitudinal and lateral ribs 82 and 84, respectively, may form a plurality of cavities 98 that may or may not include a hole 100 (thirteen shown but only one labeled for clarity) to allow air to pass from a cavity 98 toward an arch portion 102. The plurality of cavities 98 may include circular shaped cavities, pentagonal shaped cavities and trapezoidal shaped cavities. For example, in one embodiment the orthotic 80 may include two circular cavities 98a having a diameter between 10 and 15 millimeters, two other circular cavities 98b having a diameter between 15 and 20 millimeters, two pentagonal cavities 98c and six trapezoidal cavities 98d. Thus, the orthotic 40 may be made flexible enough to provide comfort while walking, running or performing other physical activities.